

PVSAT: Remote Performance Check for Grid Connected PV Systems Using Satellite Data

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Small photovoltaic (PV) systems (i.e. in the power range of 1 to 10kWp) regularly do not include any long term surveillance mechanism. As most system operators are not PV specialists, partial system faults or decreasing performance may not be recognized. Regarding a number of several thousand systems being in operation today, remarkable losses in energy production may occur.

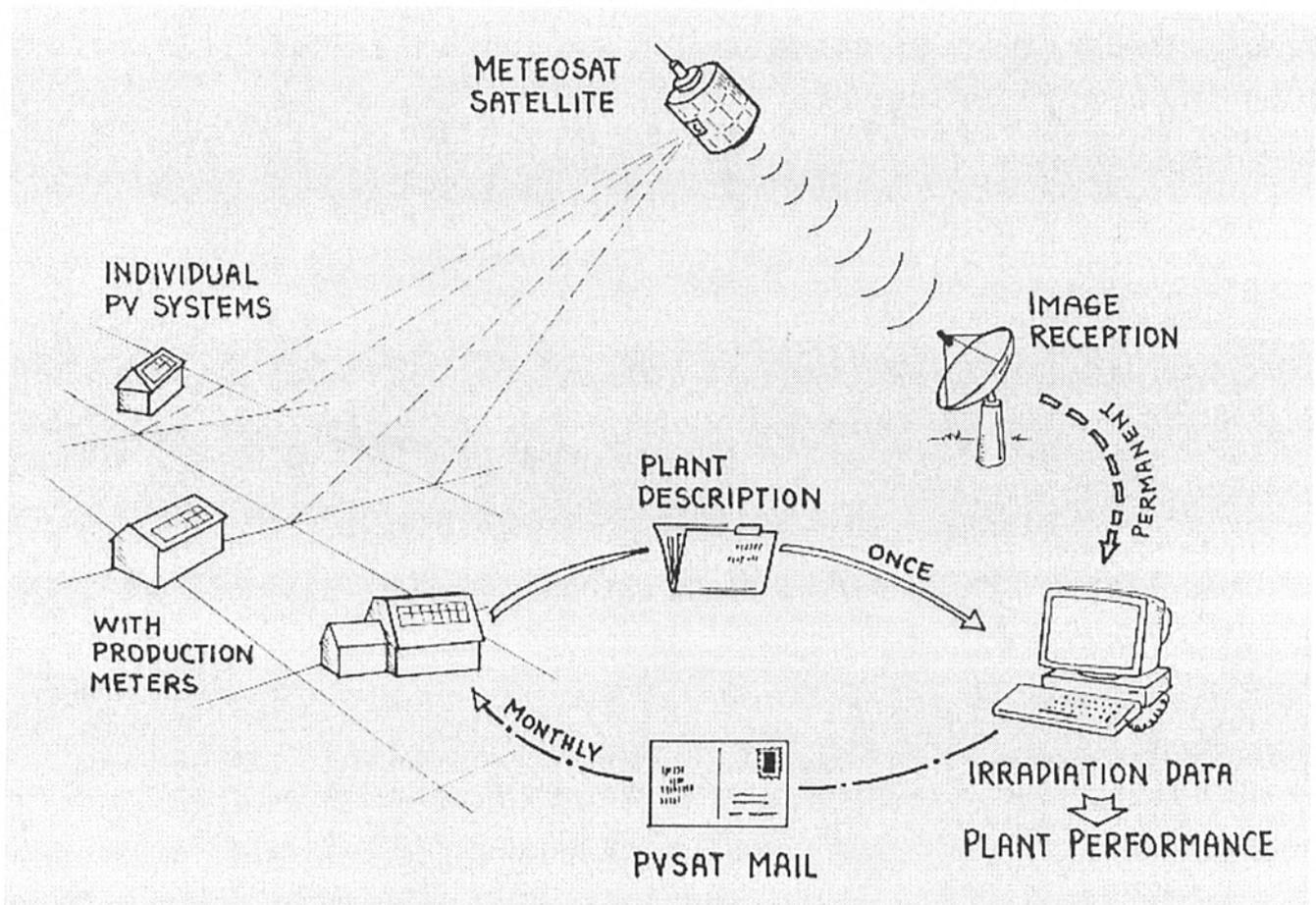
The European research project PVSAT will set up a remote performance check for small grid connected PV systems. No additional hardware installation will be necessary on site. The site specific solar irradiation data will be derived from satellite images rather than from ground based measurements. On the basis of monthly irradiation time series, monthly val-

ues of PV system yield will be calculated and distributed automatically via postcard, fax or e-mail (whatever is most suitable) towards the system operators. This procedure will remind the system operator periodically to check the performance of his installation. In this way, a high system performance will be ensured over the whole lifetime of a PV system.

At this time, we will not be able to show real results of a working PVSAT procedure, as the project has started some 8 months ago. Instead, we will present the project outline and the specific tasks of our work, including a discussion of accuracy issues (which kind of failures may be detected) and of the end users' (small systems' operators) benefits.

PVSAT:

Remote Performance Check for Grid Connected PV Systems Using Satellite Data



EU Joule III: Contract JOR-CT98-0230



Fraunhofer
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Solare Energiesysteme

Presentation: PVSAT by C. Reise, ISE

Project Partners:

Fraunhofer ISE,
Freiburg (D)

Enecolo AG,
Mönchaldorf (CH)

Utrecht University,
Utrecht (NL)

Universität Oldenburg,
Oldenburg (D)

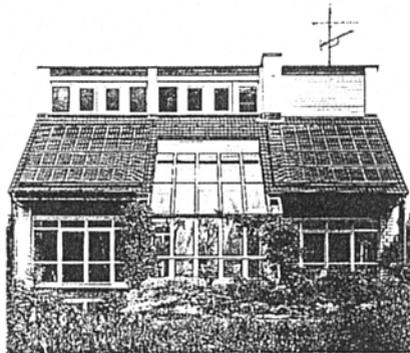
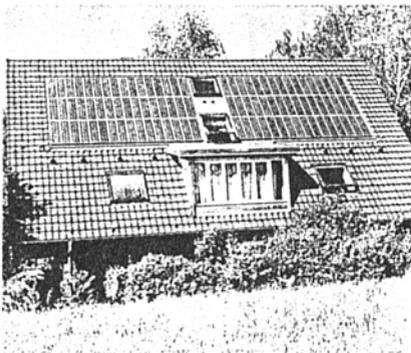
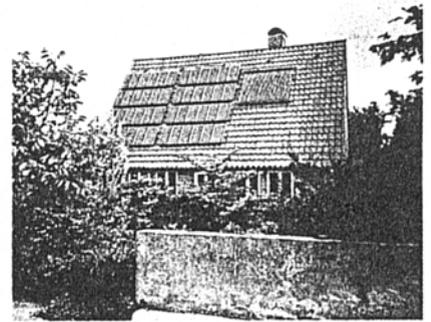
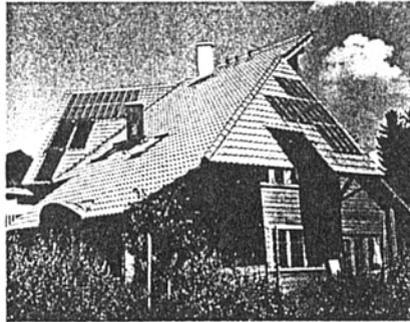
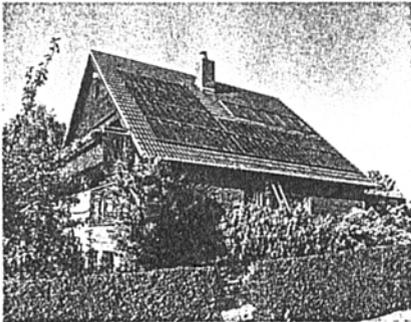
Energy Consulting, Aix en Provence (F)
Fachhochschule Magdeburg, Magdeburg (D)

Deutscher Fachverband Solarenergie e.V. (D)
Deutsche Gesellschaft für Sonnenenergie e.V. (D)
Energiebüro Christian Meier (CH)
Organisatie voor Duurzame Energie (NL)



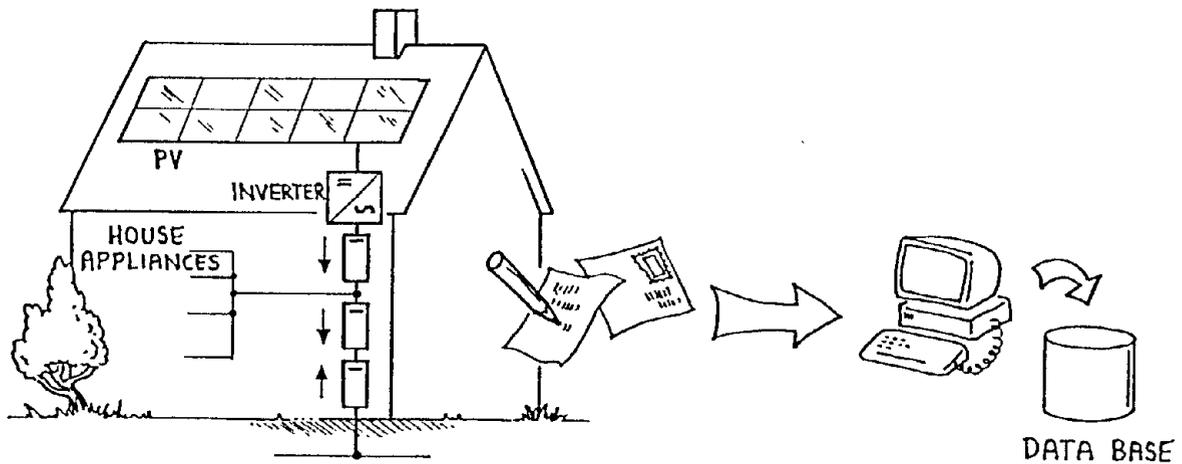
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Solar Electricity from a Thousand Roofs

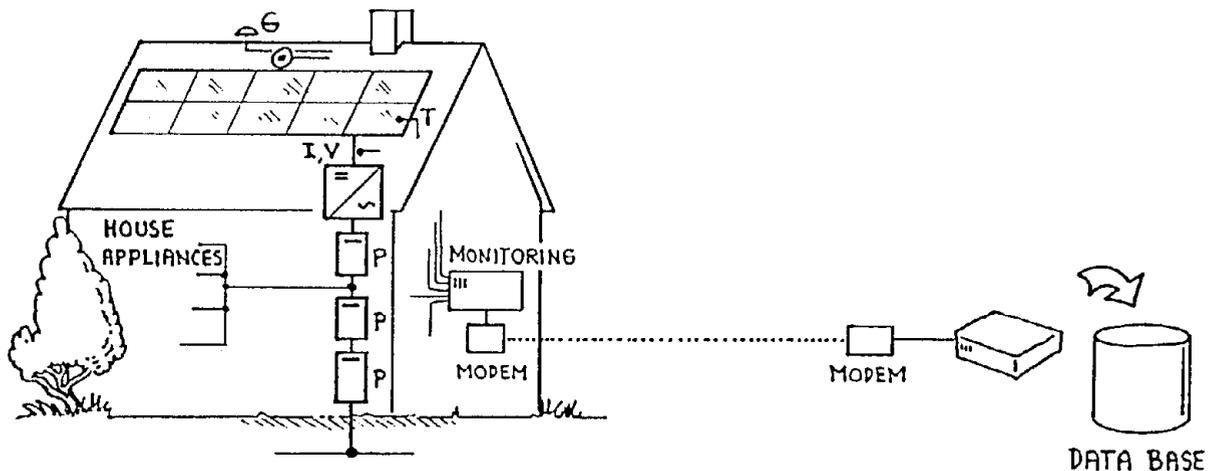


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Monitoring within the 1000 Roofs Programme



All systems: global monitoring
on monthly base



100 systems
(since 1996: 40 systems):
5 minute mean values



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Defects in PV Systems

500 failures in 2000 site-years of operation

200 failures related to the PV generator

Reasons:

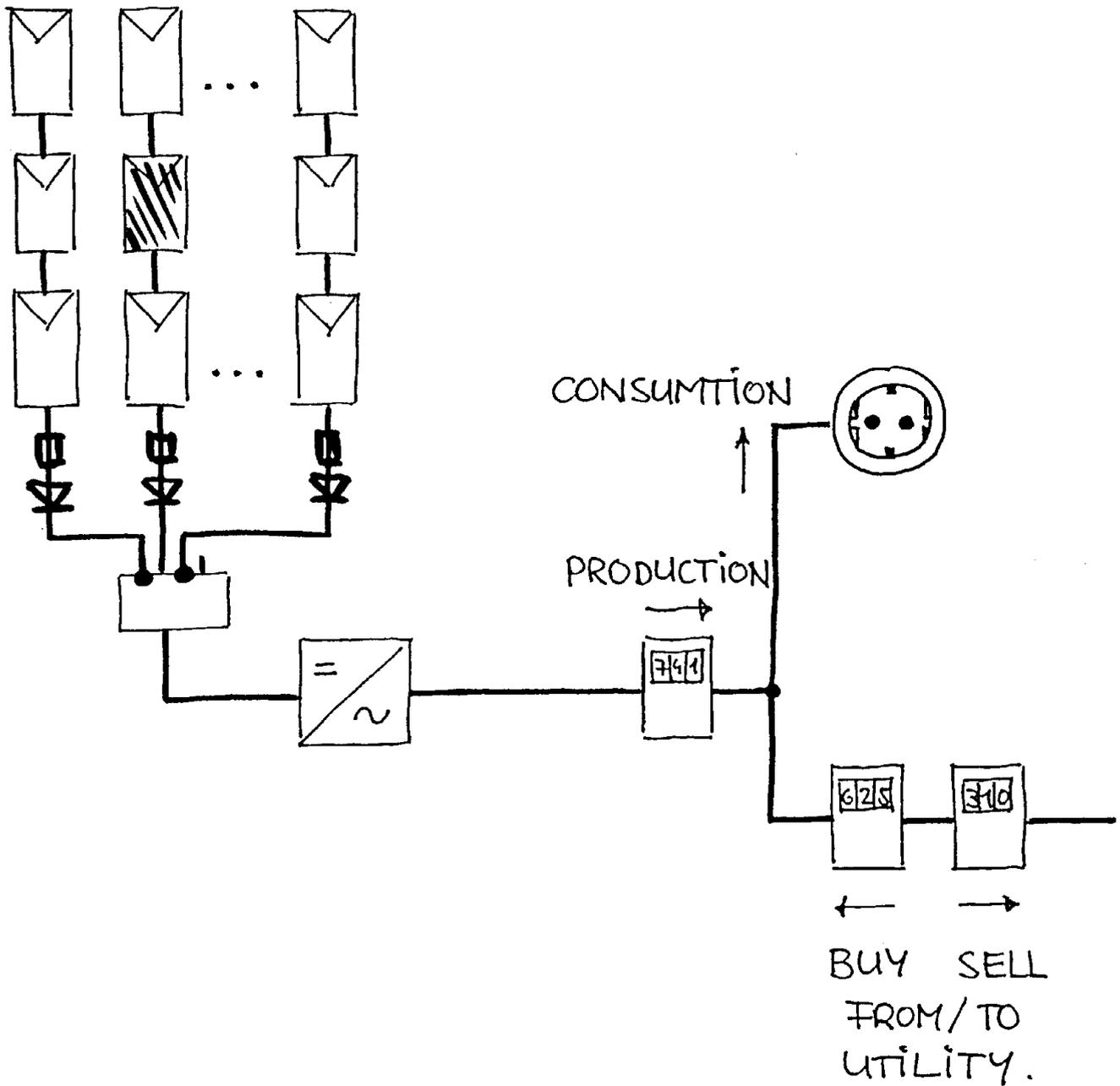
- loose terminal connections (43 %)
- module defects (14 %)
- string diode defects (14 %)
- string fuse defects (29 %)



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Typical Grid Connected PV System

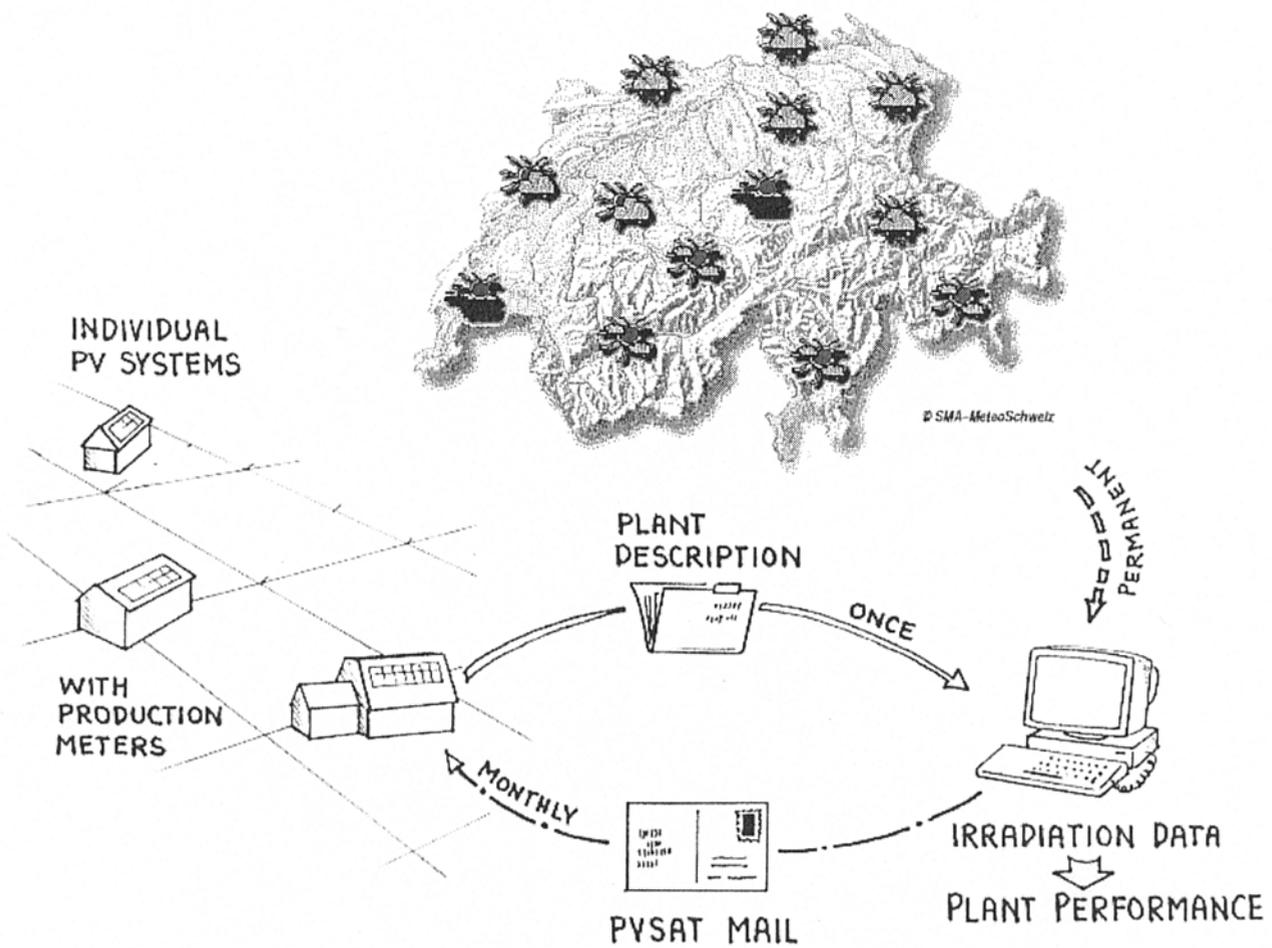


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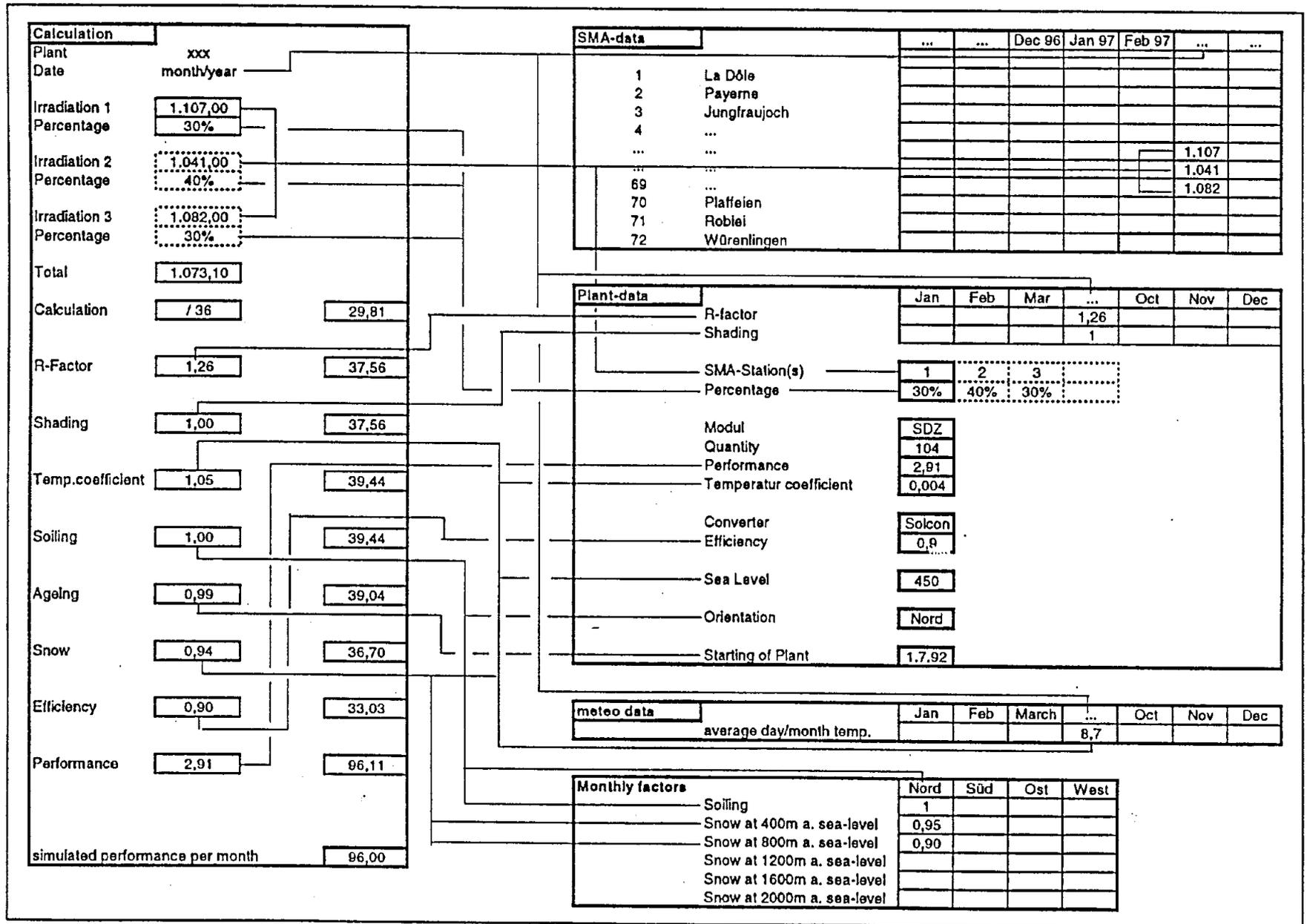
IMIPP:

Remote Performance Check for Swiss Grid Connected PV Systems Using Ground Data



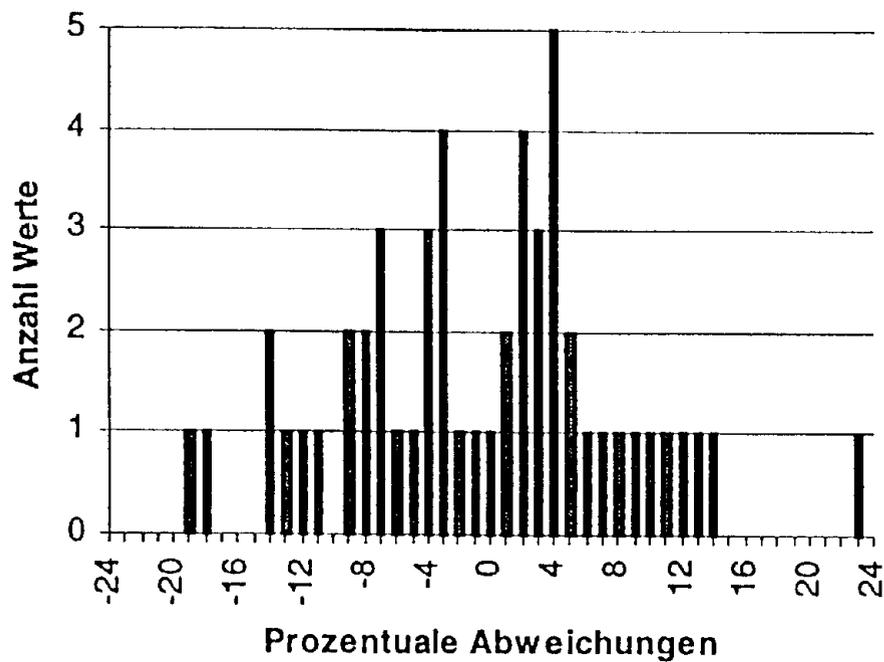
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Prediction accuracy

IMIPP estimation vs.
observed plant yield



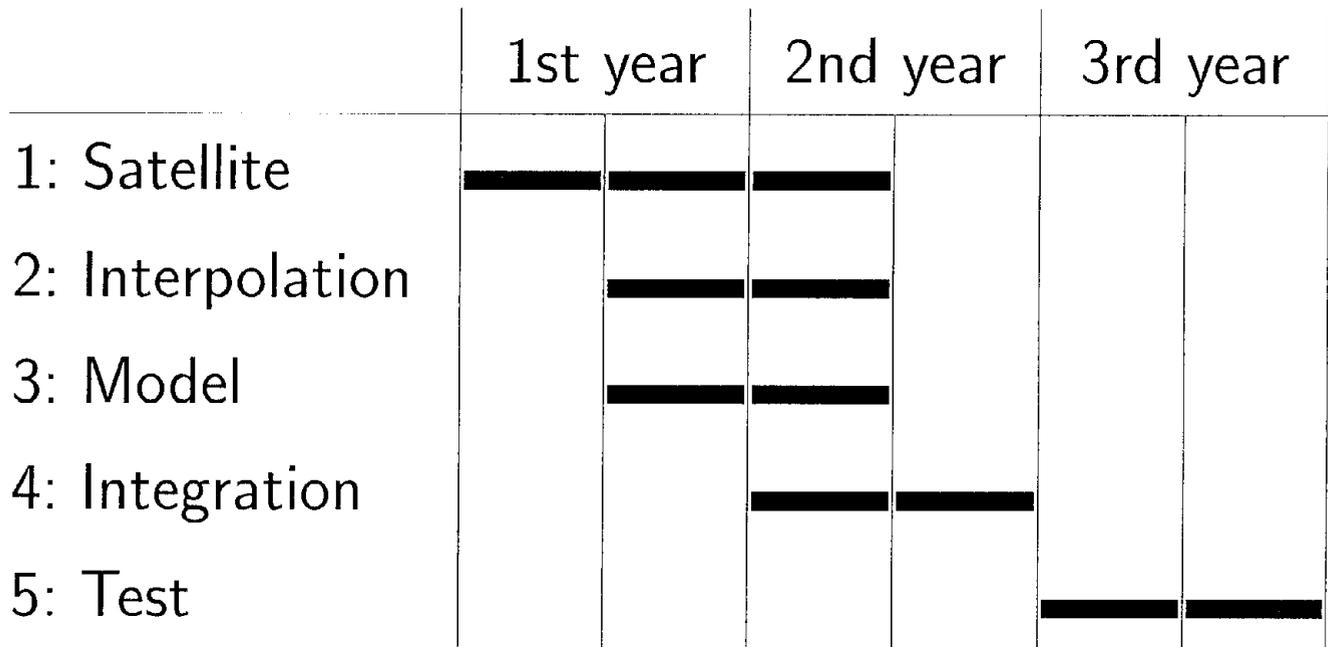
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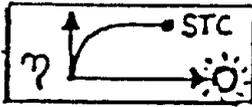
Project Structure

- Task 1 Satellite data production
- Task 2 Ground interpolation techniques
- Task 3 PV system model
- Task 4 PVSAT integration
- Task 5 Test & evaluation

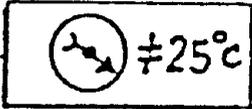
Project time schedule



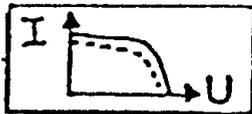
PV system modelling



Irradiation affects efficiency



Temperature affects efficiency



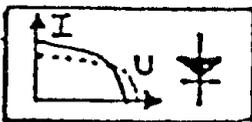
I/V-curve fit correction



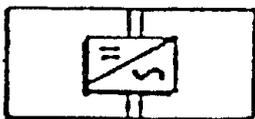
Shading losses



MPP tracking mismatch



Cables, diodes, fuses,
I/V-curve mismatch



Inverter losses



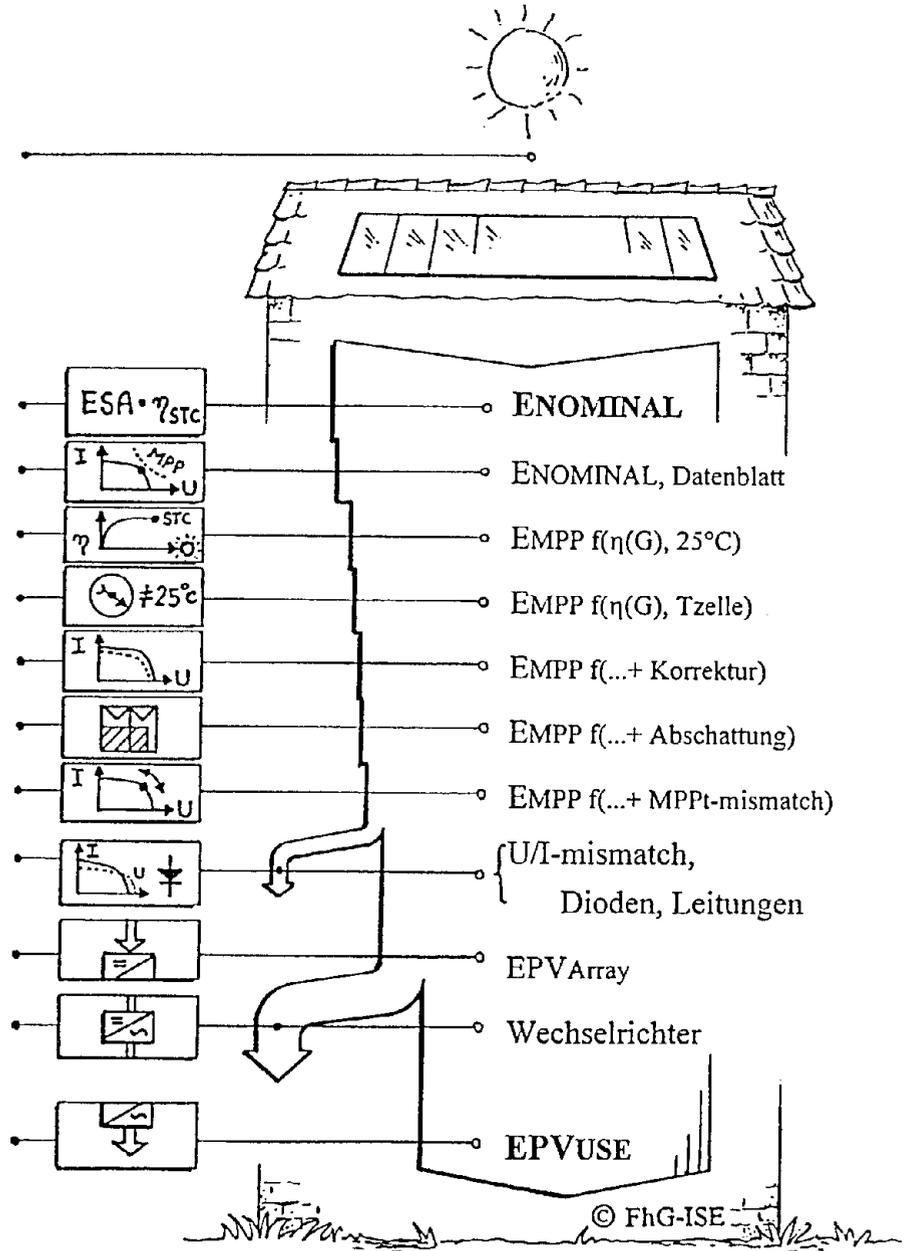
1000 Roofs Programme

Energy Flow Analysis

2.544 PNOMINAL [kW_p]
 20.48 Generatorfläche [m²]
 20072 ESA_{28°} [kWh]
 12.42 η_{STC} [%]

Messung Simulation
 kWh % kWh %

2493	100	2493	100
		2485	99.7
		2386	95.7
		2237	89.7
		2215	88.9
		2170	87.0
		2133	85.6
			3.6
2128	85.4	2044	82.0
	5.1		4.5
2000	80.2	1931	77.5

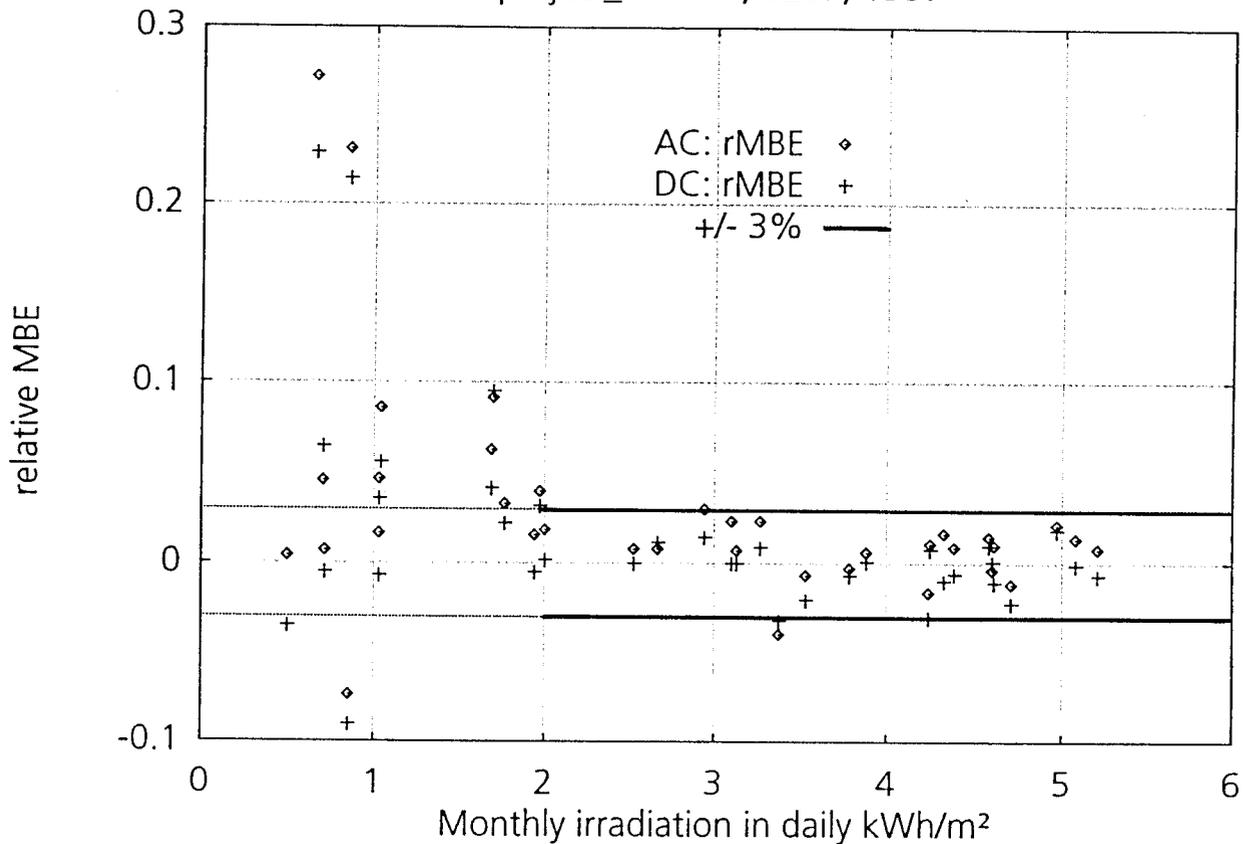


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Base level, 3 systems

project_id 0042, 0237, 1357



* Mean Bias Error of simulated and measured AC power generation remains in a bandwidth of approx. +/- 3% for monthly irradiation > 2 kWh/m² per day

* With the exception of shading periods, the mean bias error is within +/- 10% in low irradiation periods



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PV system modelling

Simplifications with level 2: Constant mismatch factors

Module temperature calculated from ambient temperature

Module irradiation calculated from horizontal values

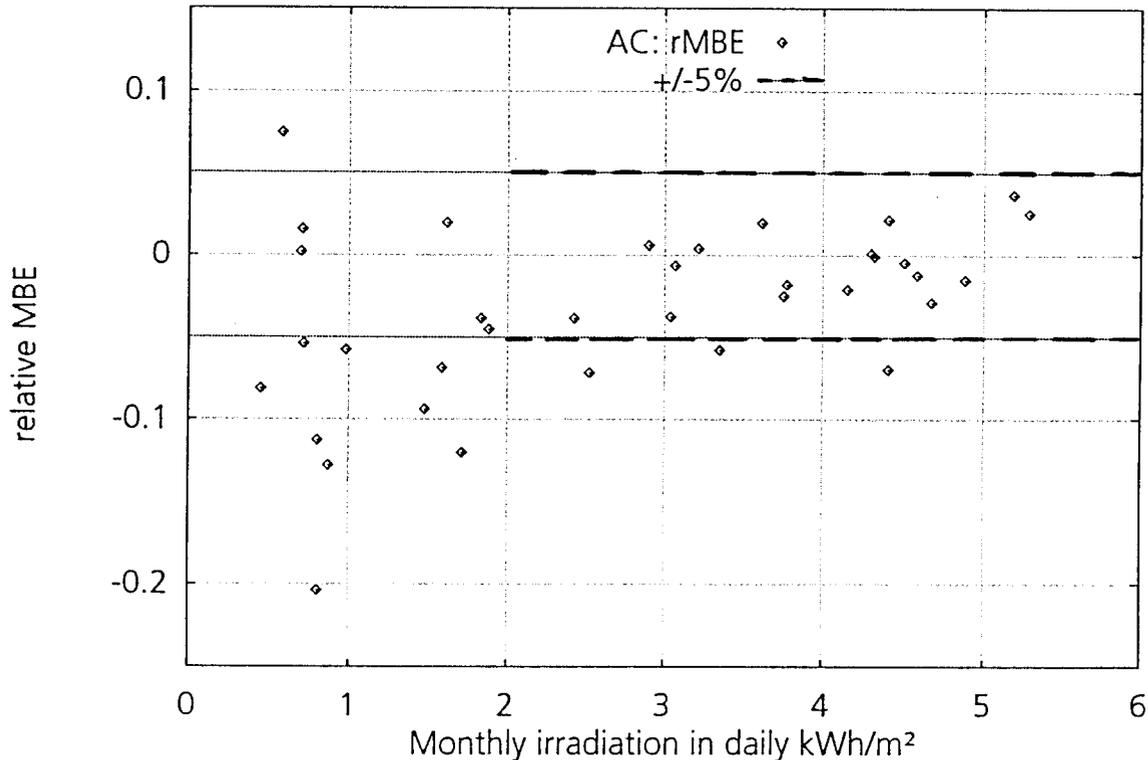


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Level 2, three systems

project_id 0042, 0237, 1357



Result of level 2 simulation:

The use of measured horizontal irradiation approximately doubles the mean bias error of simulated AC power generation compared to the measured values:

- * The error exceeds the $\pm 5\%$ margin and is $< \pm 10\%$ for monthly irradiation > 2 kWh/m² per day
- * In low irradiation periods, errors of $> \pm 10\%$ may be observed



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PV system modelling

Simplifications
with level 2:

Constant mismatch factors

Module temperature calculated
from ambient temperature

Module irradiation calculated
from horizontal values

Further
problems:

Ambient temperature estimated

Insufficient component data

No site specific knowledge

Irradiation from satellite data



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